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This report is presented in four parts. Part one presents a philosophy of agricultural education. Part two describes the role of the biological sciences in agricultural education, important biological principles and concepts, and suggested programs for prospective students. Part three includes a discussion of the role of mathematics, chemistry and physics in agricultural education. Part four, the appendix, presents a discussion of the essential concepts in an agricultural education curriculum. This report is made with consideration of the following anticipated developments: (1) the continued importance of agriculture and the biological sciences on the national and international scene, (2) the critical shortage of agricultural educators both now and in the future, (3) the recognition that agricultural education is a broad field requiring generalists and specialists, (4) the need to improve the biological science preparation of agricultural educators, (5) the belief that agricultural educators need initial understanding of basic biological principles and concepts, and (6) the continued need for providing additional emphasis and reinforcement of these basic principles and concepts. (BC)

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Report of the

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SUMMARY OF REPORT

It is the judgment of the committee that agricultural education of the future will be employed in many different situations serving people with diverse educational needs and interests. They will work as vocational-technical educators in schools, as general educators in schools and in other educational settings, as agricultural education consultants, as agricultural education administrators, and as agricultural educators in other cultures. They will all need a basic understanding of the fundamental principles of biological sciences. Because of these varying responsibilities and differing degrees of specialization needed by future agricultural educators, the amount and kind of biological science education they should receive will vary.

Considering these anticipated developments, the committee report reflects the following:

1. The continuing importance of agriculture and the biological sciences on the national and international scene;

2. The critical shortage of agricultural educators for staffing present and new and expanding programs;

3. The recognition that agricultural education is a broad and diverse field, requiring the services of both general and specialized teachers and other personnel;

4. The need to improve the biological science preparation of the agricultural educators;

5. The belief that agricultural educators need initial understandings of the basic biological principles and concepts which are necessary for subsequent courses in biological science and agriculture; hopefully, these initial understandings in biological sciences, physical sciences, and mathematics can be developed in one college year.

6. The continued need for providing additional emphasis and reinforcement of these biological science concepts from supporting and related instruction which follows or is taken concurrently with the courses designed to provide understandings of basic biological science principles and concepts.

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REPORT OF BIOLOGICAL SCIENCES ACTION COMMITTEE

ON AGRICULTURAL EDUCATION

Agricultural education is one of the expanding and dynamic fields which draws heavily on the biological sciences for its teaching content. Since agriculture is of continuing importance on the national and international scene, it is paramount that additional emphasis be placed upon the needs in the biological sciences for those pursuing undergraduate studies in the broad field of agricultural education.

The primary focus of this committee report concerns instruction in biological sciences for the agricultural educator at the baccalaureate level. It is recognized that a substantial number of agricultural educators enter the teaching field with the bachelor's degree and that a sizable protion return for additional work towards master's and doctoral degrees with some emphasis toward the social sciences. However, one thing stands out. There is an expanding demand for agricultural educators as teachers and in other educational roles.

The committee recognizes the risks of projecting for the future. The material presented herein is intended to reflect the increased demands to be placed upon the agricultural educator ten to fifteen years from now. Therefore, considerable flexibility is contained within the report in anticipation that baccalaureate-level education in the future will undergo continuing change and adjustment.

PHILOSOPHY

Agricultural Educators--A Definition

To understand the biological sciences education needed in agricultural education curriculums, it is necessary to define who is to receive this type of education, their present and future role in our culture, and the conditions and situations under which they will function. Agricultural educators have extensive preparation in agricultural disciplines and also have been trained to teach others who are engaged in, or are preparing to engage in, agricultural pursuits or applied biological science pursuits requiring knowledge and skill in agricultural subjects. The agricultural educator is characterized by his knowledge and understanding of the teaching-learning process.

Agricultural educators may teach, organize or administer programs, and they may be classified in different ways. One method of classification may relate to where they work. Agricultural educators may be employed by (1) elementary schools as consultants, (2) junior high schools to teach applied

biological science, (3) high schools to teach agriculture as a vocational subject or as a general education subject, (4) junior colleges and post-high-school vocational and technical institutions to teach technical level courses in agriculture, (5) agriculturally oriented industries to organize personnel improvement and consumer education programs, (6) higher education institutions to offer extension and non-credit courses in agriculture, and (7) international education programs to provide consultant and other educational services in agriculture.

Agricultural educators also may be classified by the kinds of programs offered. For example, agricultural educators provide education for (1) off-farm agricultural business and industry occupations, (2) applied biological science occupations in which knowledge and skill in agricultural subjects are needed, (3) renewable natural resources occupations, (4) ornamental horticulture occupations, (5) farming and ranching occupations, (6) practical arts education in agriculture, and others.

Education and Society

Our society is becoming more and more dependent on education. The need for agricultural education in formal education programs, in business, in farming, in international programs, and for the worthy use of leisure time is increasing and will probably continue to increase. The complexity of our society and its propensity for rapid change dictate that agricultural educators of the future should have a basic understanding of the fundamental principles of biological science.

It is likely that agricultural educators in the future will be working in teams in institutions and business establishments of increasing size. This will permit and necessitate specialization in the various disciplines of agriculture. Both rural and metropolitan schools are seeking and employing agricultural educators to teach courses for persons engaged in, or preparing to engage in, agriculturally-oriented businesses in such areas as fertilizers, chemicals, seeds, and agricultural machinery and equipment. For some students these courses, or special sections of these courses, may lead to employment immediately after high school, but the instruction they receive provides a basic education in agriculture.

Agricultural education programs and courses are being expanded at the high school, the post-high school, and the adult education levels. Consequently, the biological science education needed by education personnel in these programs will differ, depending on the type and degree of agricultural specialization.

Future Roles of Agricultural Educators in Schools

Agricultural education in schools is changing at an accelerated rate and will continue to change because of legislation and socio-economic trends. There are "new" agricultural education programs emerging in schools which parallel the revolutionary developments in other areas of the curriculum.

Schools of less than baccalaureate level are continuing to provide education for farming and ranching, but they are not limited to this type of agricultural education. Courses and programs are being established to educate employees for governmental agencies and private industry. These jobs involve knowledge and skill in the agricultural disciplines. Metropolitan areas are discovering the need for agricultural education programs in ornamental horticulture, floriculture, care and management of ornamental trees in parks and golf courses and along the streets, and animal science relating to small and large animals. Teachers are also in demand in metropolitan areas to offer similar courses of a nonvocational nature.

Other Roles of Agricultural Educators

Agriculturally oriented businesses and industries are employing increasing numbers of agricultural educators to plan, organize, and assist in conducting the educational programs for their customers and their employees. Human and economic development programs such as the Job Corps and VISTA are seeking agricultural educators to staff parts of their educational programs.

It may be that one of the greatest demands for agricultural educators in the next two or three decades will be in international education programs, including the Peace Corps and missionary programs. Agricultural educators in international education programs will need to understand the fundamental principles of biological and agricultural sciences to handle successfully the new and unfamiliar situations they will encounter.

THE BIOLOGICAL SCIENCES IN AGRICULTURAL EDUCATION

The Role of the Agricultural Teacher

The teacher of agriculture in junior high schools, high schools, community colleges and technical institutes, is, for the most part, a teacher of applied biology. Utilizing his knowledge of the teaching-learning process, his major role is to help young people understand and apply the principles of biology to plants and animals common in agriculture. The tremendous expansion of knowledge in biology, and the change in the approach to and procedure for the teaching of biology in college, make it imperative that attention be given to the preparation of teachers of agriculture in the basic biological sciences. While the trend in subject matter preparation for teachers of agriculture and other agricultural educators is toward more specialization, all will still continue to need a general, basic background in the biological sciences. It is this general preparation to which this section is focused.

Curriculum Patterns

The typical curriculum for the preparation of agricultural educators includes about equal emphasis upon (1) general, basic courses and (2) the special, applied courses in a field of interest. Thus, it is particularly essential that there be coordination between the courses in the basic sciences and the applied courses which follow. For example, it is essential that the instructor in a course such as forage crops be familiar with the concepts and principles of biology taught in the basic courses. With this knowledge, he can emphasize and reinforce the understanding and application of these principles in the presentation of the subject matter in his course. Unnecessary duplication of efforts can likewise be minimized.

Requirements to Achieve Understanding in Biological Sciences

The questions that may be posed are as follows: How much biology, or what depth of biology, should be considered as ideal for the agricultural educator? How will the knowledge of basic biological concepts best serve the individual? How much of his time may profitably be devoted to the acquisition of this knowledge? Are the basic requirements in biology in the colleges of agriculture throughout the country sufficient for his needs?

The diversity of existing programs indicates that there are no universal answers to these questions. There are, however, certain basic areas regarding living systems which should be familiar to the agricultural educator. The formal structure by which this familiarity is developed is not as important as the knowledge or appreciation of the fundamental requirements of living organisms. The understanding of these requirements will provide a foundation for the application of knowledge that will best serve mankind.

Stated simply, it is the understanding of life processes. Life may be defined as the "expression of a miracle," but this doesn't mean an unawareness of some of the conditions that must prevail in order for the miracle to be accomplished. Indeed, with knowledge, the expression may be modified or, for that matter, be suppressed in instances where the latter is preferred.

These fundamental requirements are as necessary for the amoeba as for man, for a single alga cell as for an oak tree. Briefly stated, they are as follows:

(1) Nutrition
(2) Gas exchange
(3) Waste disposal
(4) Water
(5) Control
(6) Reproduction

In addition to these fundamental requirements of the living organism, it is desirable that there be developed an understanding of man's role in biology.

In order to understand the uniqueness of biological systems, it is important that the student develop some appreciation of some basic physical and chemical phenomena. The processes of diffusion, radiant energy, and the inability of an organism to survive in a closed system are but some of the important aspects which must be understood. This is not to imply that chemistry and physics should be prerequisite to initiate studies in biology. It does mean that the teacher should employ the necessary basic principles relating to physical and chemical phenomena in order to implement the understanding of living versus non-living.

A sound, fundamental education in the six topic areas previously mentioned should provide insight for all biological systems. The "why" of biology needed by the agricultural educator may be developed through the amplification of the six requirements of living organisms.[1/] It is not necessary to dwell on the diversity of plants and animals, but rather to appreciate the application of these six topics. The many and varied expressions of form are merely nature's way of exhibiting various adaptations for accomplishing the same goal. The replication of these expressions is best left for advanced studies which follows the instruction relating to concepts.

Principles and Concepts

Since there is a great diversity among institutions regarding how courses in biology are organized, and how content is allocated to the various courses, this committee has chosen to make its recommendations on needs in biological sciences in terms of those principles and concepts it believes agricultural educators must understand to teach adequately the science of agriculture.

This committee believes the basic goal for biology instruction should be an understanding of the requirements of a living system, its structure and function. To accomplish this, the preparation of agricultural educators should contribute to giving the students an introductory understanding of the following principles and concepts basic to agriculture:

1. The concept that all things living and non-living are either matter or energy, or a combination of these

2. The characteristics of living and non-living matter

3. The classification of living organisms by similarity of structure and function

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1/ An elaboration of the six requirements of living organisms is included in Appendix A.

4. The adaptation of living organisms to their environment

5. The process of diffusion in all living organisms and its significance to life

6. The process of photosynthesis

7. The process of growth in living organisms

8. The organic cycle and its importance to plant and animal life

9. The specialized chemical substances which regulate the life processes of growth and development

10. The malfunctions which limit the normal processes of living organisms

11. The reproduction process in living organisms

12. The response of living organisms to stimuli

13. The nutritional requirements of plants and animals

14. The processes of transpiration and respiration and their importance in living organisms

15. The movement of substances in living organisms

16. The nervous and endocrine systems of higher animals

17. The skeletal and muscular systems of living organisms

18. The function of excretion and secretion in plants and animals

19. The principles of heredity in living organisms

20. The principles of interrelationship of living organisms

21. Man's control of and adaptation to his environment

22. The uniqueness of man as a living organism capable of transmitting knowledge

Suggested Programs for Persons Preparing for Agricultural Education

The question of depth in biological science for the agricultural educator cannot be answered definitively. The multiplicity of disciplines

in agriculture for agricultural educators precludes a prescribed number and kinds of courses. Hopefully, the basic concepts and understandings necessary for the agricultural educator, as delineated earlier in the report, could be provided in one college year. It is desirable that these principles be reinforced and developed further in other courses in the student's program.

Because of the unique role of the agricultural educator as a teacher of applied biology, entry into applied biology courses should be made as early as possible. Many students, because of their specialized interests and requirements, may need additional courses in applied biology or biology, recognizing that all biology is not incorporated in the introductory courses or provided in courses identified by title as "biology."

PHYSICAL SCIENCES AND MATHEMATICS

Relationships

Mathematics, chemistry and physics, along with the biological sciences, are foundation disciplines for modern applied agriculture. Each is necessarily interrelated with the other on the basis of common subject matter and method. Therefore, this section is directed toward requirements in mathematics, chemistry and physics needed to precede or complement basic biological science courses to be taken by students in agricultural education. In the future, if the minimum requirements stated below have not been met, additional work should be taken in these areas. Those developing teaching specialties will, in some cases, need to go beyond these requirements.

Further, the committee believes that if introductory courses are oriented toward the general student body, courses for non-majors would not be needed. Conversely, if such courses are not available, then specific courses for non-majors in these fields should be established.

Mathematics

College algebra and trigonometry will meet the needs of the student in basic courses in the biological sciences as identified in this report.

Chemistry

A year of inorganic and organic chemistry will serve the students in this curriculum.

Physics

All students should have a minimum understanding of basic concepts of sound, heat, mechanics, electricity, energy and light.

Additional Requirements for Teaching Specialties

Students developing teaching specialties would pursue sequential courses in related sciences. Students developing a teaching specialty in agri-business may need one or more courses in statistics and related fields. Those specializing in plant and animal sciences may need courses in biochemistry, physical chemistry and colloidal chemistry. For those students, an understanding of calculus is essential. Students developing a teaching specialty in agricultural engineering will need courses in calculus and in some cases additional physics.

APPENDIX A

In order to communicate the meaning of the six requirements of living organisms, the committee includes the following elaboration as a part of this report.

Nutrition

A primary consideration is the proper appreciation of the uniqueness of protoplasm. What is life? What sustains it? Any living system requires the input of energy, and for this reason, it cannot survive in a closed system. At this level the characteristics of protoplasm are best understood from the standpoint of the protoplast (cell). Thus, the interrelationship of structure and function in the protoplast can be discussed in terms of the acquisition and use of energy. Other sub-topics under nutrition are:

Photosynthesis - including an explanation of how radiant energy is transformed into chemical energy

Metabolism - the synthesis of food (carbohydrates, proteins and fats) in both autotrophic and heterotrophic forms

Respiration - the use of food to provide energy, including heat and other forms; the use of food for synthesizing new protoplasm in the form of DNA and RNA and others

Movement - internal protoplasmic streaming (cyclosis), movement in higher plants, and locomotion in animals. This would, of course, include movement of substances in the vascular tissues of plants and animals as well as methods of locomotion. It would include the acquisition (herbivores, carnivores, etc.), distribution (phloem, circulatory mechanisms, etc.), and utilization of foods.

Some of these topics, especially metabolism, respiration and replication, are part of the well-known "molecular biology;" but the emphasis should be placed on the needs of a living system, i.e., the organism, whether a single protoplast or higher animal. The student should be able to relate these topics to any living system.

Gas Exchange

All living systems require some method of gas exchange. This, again, is a physical process and requires a thorough understanding of diffusion.

There are three basic requirements in the gas exchange situation, whether it involves a single protoplast or a higher organism--plant or animal:

(1) There is a relatively high concentration and constant course of O_2 separated by

(2) a moist, selectively permeable, thin membrane, from

(3) a relatively high concentration of CO_2.

Only a few examples need to be cited in order to illustrate this principle.

As a corollary, it should be mentioned that a moving fluid or column of air is necessary to maintain the concentration gradients. Thus, whether the membrane is the plasma membrane of a single protoplast, gills, body surface or lungs, the concept is the same. For example, nearly every protoplast in a large tree is exposed either directly or indirectly to these conditions. It is not really necessary to list ad nauseum the many refinements or adaptations to this principle. Such discussion may be deferred to subsequent courses or at least to a section, in this course, on diversity of organisms.

Water

Water is absolutely essential to all living systems. Every student should develop an appreciation and awareness of its importance. Approximately 80 percent or more of protoplasm is water, and its role in metabolic activities cannot be overemphasized. The homeostasis, or dynamic equilibrium, of the organism is associated intimately with water content and its use.

Water gain must equal water loss, and the manner in which this is accomplished varies considerably in marine, fresh-water and terrestrial habitats. Whether water content is regulated by an osmo-regulatory organelle such as the contractile vacuole in amoeba, by the kidney in vertebrates, or by transpiration in plants, the basic features are the same.

The conservation of water becomes a primary factor for many organisms and, for mankind, may even be a critical one unless we deal promptly with continued water pollution.

Waste Disposal

Many end products of metabolism are not useable by the organism and, indeed, some are even toxic. Nitrogenuous substances, for example, ammonia, must be transformed into nontoxic substances or voided immediately.

Organisms have adapted many ways for getting rid of wastes. Trees, for example, deposit these in non-living parts of the plant where they are no longer toxic and simply "grow off and leave them."

The homeostatic relationship with water regulation is obvious. Many organisms dilute their wastes with water before eliminating them. Thus, every organism, without regard to its complexity, has this common problem. There are, of course, other aspects of this problem but the diversity with which living systems have met the problem is beyond a detailed discussion at this point.

Control

One of the best characteristics of a living system is the high degree of organization. Nowhere is this more apparent than in the integrated and well-coordinated nervous and chemical activities in the organism. Again, this principle of homeostasis, or dynamic equilibrium, must be appreciated and understood. In addition to nervous and chemical controls, the student should appreciate the influence of environmental controls on the activities of biological systems. The latter can be briefly illustrated, and subsequently enlarged upon in ecology courses and others.

Reproduction

Some aspects of this topic, at least the replication of a living system, were discussed earlier. Since all organisms are reproduced at the level of the protoplast, regardless of their subsequent complexity, the basic features of both sexual and asexual reproduction could be discussed earlier, or concurrently with genetic principles. Some instruction on heredity, biotic potential, and continuity is an essential part of the beginning course. This also provides logical insight into a discussion of organisms at the community level and extends the students' thinking beyond the single individual. This involves the interrelationships of the organism with its environment and with other organisms.

Before proceeding to man's role in biology, we may briefly summarize to this point. All of the topics mentioned above can be discussed in terms of "patterns of differentiation in plants and animals." The idea is to present fairly familiar plants and animals from the standpoint of how they have been able to accomplish these basic requirements. This leads into the diversity of organisms but maintains a central theme of discussion. In other words, the diversity is but "variations on a theme." Hopefully, this will encourage the student to see the unity of life rather than the multitude of confusing, factual information associated with an array of diversified forms.

Now, what is the role of man in biology? Man, as a biological entity, is subject to the same requirements as any other living system, but there are greater implications due to the very nature of man. Were it left to nature alone, the patterns of differentiation and consequences of genetic variability would be more or less fortuitous. Man, however, has the capability of superimposing his own designs in many biological affairs. He may enhance or suppress certain natural processes toward his own well-being and in this regard he is a very unique biological system.

Therefore, the beginning course would be remiss if it did not touch upon such subjects as:

Technological breakthroughs, such as space biology, that influence or relate to living systems;

The conservation of natural resources;

The human population explosion;

Providing food for mankind;

And many others.

Here, of course, we touch upon many disciplines of science and the efforts to utilize the total knowledge of mankind. It is here that we see the relationship of biology to sociology, psychology, economics and other areas of knowledge.